October 2, 2018

Austin Hofmeister
Program Administrator – Petroleum Restoration Program
Florida Department of Environmental Protection
3900 Commonwealth Boulevard
Tallahassee, FL 32399

Re: Health Consultation: Indoor Air Sampling Events Saint Andrew's School, Boca Raton, Florida

Dear Mr. Hofmeister:

The Florida Department of Health (DOH), Public Health Toxicology Section is committed to ensuring that people at contaminated sites have the best information available to understand the chemicals and the health risks.

Previous petroleum tank storage on the property of Saint Andrew's School in Boca Raton, FL was associated with contamination of soil and groundwater which in turn posed a contamination of air through vapor intrusion. A remediation effort was established to minimize exposure of students and workers to the contaminated media. Recent testing (2018) found benzene, toluene, ethylbenzene, total xylenes, and methyl tert-butyl ether in indoor air samples in the administrative building of the school. It was requested that DOH assesses the possible public health threat posed by the vapors of each contaminant.

The assessment provided in this letter required the use of assumptions, judgments, and incomplete data. These factors contribute to uncertainty in evaluating a possible health threat. Assumptions and judgments in this assessment were protective of public health and may therefore overestimate the risk.

Based on a review of available data, DOH concludes that air with the highest level of benzene will not cause non-cancer health effects. DOH further concludes that the vapor concentration measured may pose an extremely low risk of cancer.

The following health consultation explains how we assessed the public health threat from vapor intrusion at the St. Andrew's site.

Sincerely,

Kendra F. Goff, PhD, DABT, CPM, CEHP
State Toxicologist & Chief

KFG/jdf/gl

Health Consultation

Evaluation of Indoor Air Sampling Events

Saint Andrew's School
Boca Raton, Florida

Prepared by
Florida Department of Health
Bureau of Environmental Health

October 2, 2018

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Letter Health Consultation: A Note of Explanation

A DOH health consultation is a verbal or written response to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained which indicates a need to revise or append the conclusions previously issued.

Foreword

The Florida Department of Health (DOH) evaluates the public health threat through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry in Atlanta, Georgia. This health consultation is an assessment of the public health threat from vapor intrusion at the St. Andrew's site.

The cooperative agreement program is not regulatory (meaning the program does not oversee nor direct programs that oversee the control of environmental standards that are designed to protect public health). The cooperative agreement program is advisory and can suggest that regulatory programs or responsible parties look at certain issues of public health concern. Each program (within DOH or outside DOH) is governed by its own statutes, rules, and policies for directing clean up or mitigation of a chemical once an issue is found. The risk levels, concentrations, and inputs for these health consults represent a snapshot in time that may not be the same as what a regulatory program uses to direct their cleanup or mitigation efforts.

DOH evaluates site-related public health issues through the following processes:

Evaluating exposure: DOH begins by reviewing available information about environmental conditions at the site. It finds out how much contamination is present, where it is on the site, and how human exposures might occur. The Florida Department of Environmental Protection provided the information for this assessment.

Evaluating health effects: If DOH finds evidence that exposures to hazardous substances are occurring or might occur, it determines whether that exposure could be harmful to human health. This report focuses on public health, based on existing scientific information.

Developing recommendations: DOH outlines its conclusions regarding potential health threats posed by contaminated groundwater, and offers recommendations for reducing or eliminating human exposure to contaminants. If it finds an immediate health threat exists or is imminent, it issues a public health advisory warning people of the danger, and works to resolve the problem.

Soliciting community input: The evaluation process is interactive. Once DOH prepares an evaluation report, it seeks feedback. It shares its conclusions about the site with the groups and organizations who provided the information and it asks about the concerns of those living in communities near the site.

If you have questions or comments about this report, please contact DOH.

Please write to: Florida Department Health
Division of Disease Control and Health Protection
Bureau of Environmental Health, Public Health Toxicology
4052 Bald Cypress Way, Bin # A08
Tallahassee, FL 32399-1720
Or call: Toll free at 877-798-2772

Summary

INTRODUCTION The purpose of this report is to assess the public health threat from exposure to air with petroleum odors in and around the administrative building at the Saint Andrew's School. Congress mandates the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) assesses possible public health threats at hazardous waste sites. The Florida Department of Health (DOH) has a cooperative agreement with ATSDR for these assessments. The top priority for ATSDR and DOH is to ensure that the public has the best information to safeguard their health.

The Saint Andrew's School. site is located at 3900 Jog Road in Boca Raton, Florida.

In 1991, liquid free product was found in the compliance groundwater monitoring wells in the vicinity of the former 2,000-gallon Underground Storage Tank (UST) which was located south of the former maintenance building (currently known as the Assaf Building). In 1992, 355 tons of petroleum-hydrocarbon impacted soil was removed near the former UST.

Soil and groundwater sampled in 2013 showed exceedances of Florida's Department of Environmental Protection (DEP) industrial soil cleanup target levels (SCTLs) and groundwater cleanup target levels, respectively. Vapor analytical results were below the draft DEP and EPA indoor vapor intrusion screening criteria1 *(According to Geosyntec (2018), these criteria include Schedule A of the DEP draft Indoor Vapor Intrusion Screening Criteria and EPA's Office of Solid Waste and Emergency Response November 2002 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air for Groundwater and Soils (Subsurface Vapor Intrusion Guidance) document.)*

In July and August 2017, air sparging (AS) wells (screened from 30 to 33 ft below land surface (bls)) and soil vapor extraction (SVE) wells were installed as a mitigation remedy. In October 2017, reports were made about a petroleum odor inside the Assaf Building within an hour of the system startup. The system was turned off. A 2018 site visit reported that the odor had spread to the outdoor walkway located of the Assaf building and Surprenant Hall building. In February 2018, concentrations of 300 to 500 ppm, were measured during the operation of the air sparge and soil vapor extraction (AS/SVE) system.

DOH received a request from DEP to help respond to the health concern regarding the petroleum odors at the St. Andrew's site. DOH considers existing soil gas and indoor air test results to

	evaluate the potential for people to breathe harmful levels of chemicals at the school.
CONCLUSION #1	Measured benzene levels found in the air of the Business Office Building (Assaf Building) were above levels of health concern. Exposure from this contaminant may lead to an extremely low cancer health effect with chronic exposure.
BASIS FOR CONCLUSION #1	Based on risk calculations performed, it was determined that the calculated cancer risk range is $4.8x10^{-7}$ to $1.7x10^{-6}$. This indicates a range of 0.5 to 2 additional cancer cases in 1,000,000 for exposure to benzene vapor for 8 hours a day, 5 days a week and for a duration of 12 weeks over 25 work years.
CONCLUSION #2	The contaminants toluene, ethylbenzene, total xylenes, and methyl tert-butyl ether volatized in the air of the Assaf Building were below levels that would be a health concern for workers and students. This is based on the data results provided by the Florida Department of Environmental Protection (DEP) compared to ATSDR's comparison values (CVs).
BASIS FOR CONCLUSION #2	Based on ASTDR's comparison value (Appendix A Table A-3), these contaminants did not exceed the value and thus, will not likely cause any health effects.
NEXT STEPS #2	Repair current Air Sparge and Soil Vapor Extraction (AS/SVE) system and continue to monitor vapor concentrations.
LIMITATIONS OF FINDINGS	All risk assessments, to varying degrees, require the use of assumptions, judgments, and incomplete data. These contribute to some uncertainties of the final risk estimates. Some more important sources of uncertainty in this health consultation include exposure parameter estimates, use of modeled exposure doses, and current toxicological knowledge. DOH's health assessors do not know exactly when the vapor intrusion occurred and how levels varied over time. Because of these uncertainties, health assessors might have overestimated or underestimated risks. Therefore, this health consultation does not represent an absolute estimate of risk to persons exposed to vapors at Saint Andrew's School. This assessment required the use of assumptions and judgments, and relied on incomplete data. These factors contributed to uncertainties in evaluating the possible health threat. The human risk assessment process is conducted to be protective of the human health. Therefore, assumptions and judgments in the assessment of the area's impact on public health erred on the side of protecting public health and may have overestimated the risk. DOH provided specific public health recommendations based on toxicological literature, levels of environmental contaminants, evaluation of potential exposure pathways, duration of exposure, and characteristics of the exposed population. Whether a person

would be harmed depended on the type and amount of contaminant, how they are exposed, how long they are exposed, how much contaminant is absorbed, genetics, and individual lifestyles.

FOR MORE INFORMATION

If you have concerns about your health or the health of your children, contact your health care provider. For further health information about the St. Andrew's School site, contact DOH at 850-901-6598 or toll free at 877-798-2772.

Acronyms and Abbreviations

AP	Advanced Placement
AS	Air Sparge
ASL	Above Screening Level
ATSDR	Agency for Toxic Substances and Disease Registry
BSL	Below Screening Level
BTEX/MTBE	Benzene, Toluene, Ethylbenzene, Xylenes/ Methyl Tert-Butyl Ether
CF	Conversion Factor
COPC	Contaminant of Potential Concern
CREG	ATSDR Cancer Risk Evaluation Guide
CTL	Cleanup Target Level
CV	Comparison Value
DEP	Department of Environmental Protection
DOH	Department of Health
EF	Exposure Frequency
ET	Exposure Time
EMEG	ATSDR Environmental Media Evaluation Guides
EPA	U.S. Environmental Protection Agency
FID	Flame Ionization Detector
HAL	Health Advisory Level
IB	International Baccalaureate
IRIS	Integrated Risk Information System
MCL	Maximum Concentration Level
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	Minimal Risk Level *(An estimate of the daily human exposure to a hazardous substance that is not likely to have an appreciable risk of adverse non-cancer health effects over a specified duration of exposure)*
N	No
OVA	Organic Vapor Analyzer
RfD	Reference Dose (*Estimate of a daily oral lifetime exposure for people, unlikely to have appreciable deleterious health effects.)*
SVE	Soil Vapor Extraction
µg/L	micrograms per liter
Y	Yes

Contents

1. Statement of Issues

In July and August 2017, air sparging (AS) wells (screened from 30 to 33 ft bls) and soil vapor extraction (SVE) wells were installed at the Saint Andrew's School site as remediation tools. A system startup was conducted in October 2017 reporting petroleum odor inside the Assaf Building within an hour of the system startup. The system was turned off. A 2018 site visit reported the spread of the odor extended to the outdoor walkway located of the Assaf building and Surprenant Hall building. In February 2018, concentrations of 300 to 500 ppm, were measured during AS/SVE operation. In March and April 2018, Geosyntec conducted indoor air sampling upon request by DEP. The indoor air sampling included the collection of three 8-hour, time-weighted average indoor air samples at the three locations identified inside the Assaf Building.

DOH received a request from DEP to assist with evaluating the health concerns regarding the petroleum odors at the St. Andrew's site. DOH considers existing soil gas and indoor air test results to evaluate the potential for people to breathe harmful levels of chemicals at the school. The health assessor looks at what chemicals are present and in what amounts. They compare those amounts to national environmental guidelines. These guidelines are set far below known or suspected levels associated with health effects. DOH uses guidelines developed to protect children and workers.

2. Background

2.1 Site Description

St. Andrew's School site upon 81-acres of land and is within 5 miles radius from the Atlantic Ocean (Figure 1). The school offers a college-prep school experience, pre-K through 12th grade in the Southern region of Florida with over 1,200 students (Saint Andrew's School, 2018). The curriculum includes 46 Honors level courses, 24 Advanced Placement (AP) courses, and the International Baccalaureate (IB) Diploma Program (Saint Andrew's School, 2018).

2.2 Site History and Remediation

In 1984, a 2,000-gallon underground storage tank containing unleaded gasoline was installed south of the Assaf Building. A 500-gallon above ground storage tank with an unknown installation date, was formerly used for diesel fuel storage and was also found south of the same building (Earth Systems, 2016). Both tanks were removed in 1992. After sampling and analysis, it was determined that the soil surrounding the tanks were contaminated and 355 tons of soil were removed in 1992. In 1993, benzene, ethylbenzene, toluene, xylenes, methyl tert-butyl ether (BTEX/MTBE) and total lead were detected in groundwater samples from shallow wells in concentrations that exceeded DEP's Groundwater Cleanup Target Levels (Earth Systems, 2016). A vapor intrusion study was conducted in August of 2013, however, the sampling did not show contaminants to be above the indoor vapor intrusion screening criteria of DEP and the EPA. *(According to Geosyntec (2018), these criteria include Schedule A of the DEP draft Indoor Vapor Intrusion Screening Criteria and EPA's Office of Solid Waste and Emergency Response November 2002 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air for Groundwater and Soils (Subsurface Vapor Intrusion Guidance) document*.)

The remedial system installation process started in July of 2017 and the system was turned on in October 2017. Within one hour of the system starting up, petroleum odors were reported inside the administration building and the system was subsequently turned off. A few days later, the system was restarted with SVE recovery only to reduce the odors in the building, but not eliminating the vapors. The system was run between December 2017 and January 2018; the sparge and SVE systems were deactivated in January of 2018 per request of the school administration due to reports of headaches and dizziness after work shifts. The SVE system was turned back on in an attempt to alleviate odors in the office building, but was ultimately shut down in February 2018.

Figure 1. Saint Andrew's School, property and location.

3. Discussion

3.1 Planning and Hazard Identification

DOH discussed sample collection and data results with DEP. Communication is needed to obtain an accurate dataset that can be used for the health risk assessment. Once the data are evaluated, the specific hazards of concern and their potential threats can be identified. As a part of the planning process, the historical background of the site as well as the origin of the environmental hazards present are evaluated.

3.2 Data Evaluation

One of the most important tasks in data evaluation is the assessment of whether the data set is comprehensive enough to evaluate a possible risk. Once the dataset is determined to be comprehensive, the data can be evaluated in detail. When evaluating data, comparison values (CVs) are used to assess which chemicals need to be examined further. CVs consider the daily maximum human exposure (skin contact, inhalation and ingestions) to a chemical in a standard amount of air, water, and soil without effects on human health. Based on the data provided, calculations are performed to estimate a possible human health risk. Details about the calculations can be found in *Section 3.4.2 Health Evaluation.*

Indoor air typically contains volatile organic chemicals (VOCs) from sources such as consumer products, building materials, and outdoor air which results in what is commonly referred to as "background". The background is considered when assessing the potential for intrusion of contaminant vapors into the indoor air of overlying buildings (EPA, 2011a). Any indoor air sample collected for a site-specific assessment of vapor intrusion is likely to detect chemicals from those sources. In many cases, the compounds detected in indoor air may be the same as those present in contaminated soil or groundwater that may enter the building through vapor intrusion (EPA, 2011a). The presence of indoor and outdoor sources of VOCs can often make it challenging to assess the contribution of vapor intrusion to indoor air concentrations because it is often difficult to distinguish between background concentrations and contaminant concentrations (EPA, 2011a).

3.2.1 Environmental Data

DEP's contractor (Geosyntec) tested on-site vapor in the Assaf Building at three different locations (Figure 2). They found benzene, toluene, ethylbenzene, total xylenes, and methyl tert-butyl ether, among other contaminants (Appendix A Tables A-1 and A-2). The other contaminants found were not determinized to be of concern for vapor intrusion at this site.

3.2.2 Chemicals of Concern

The DOH health assessors evaluated sampling test results and screened site related data using ATSDR's Comparison Values (CVs). The chemical concentration for *benzene* was greater than its respective CV and was therefore investigated further. An overview of the chemical concentrations recovered at the site compared to their ATSDR CVs can be found in Appendix A Table A-3.

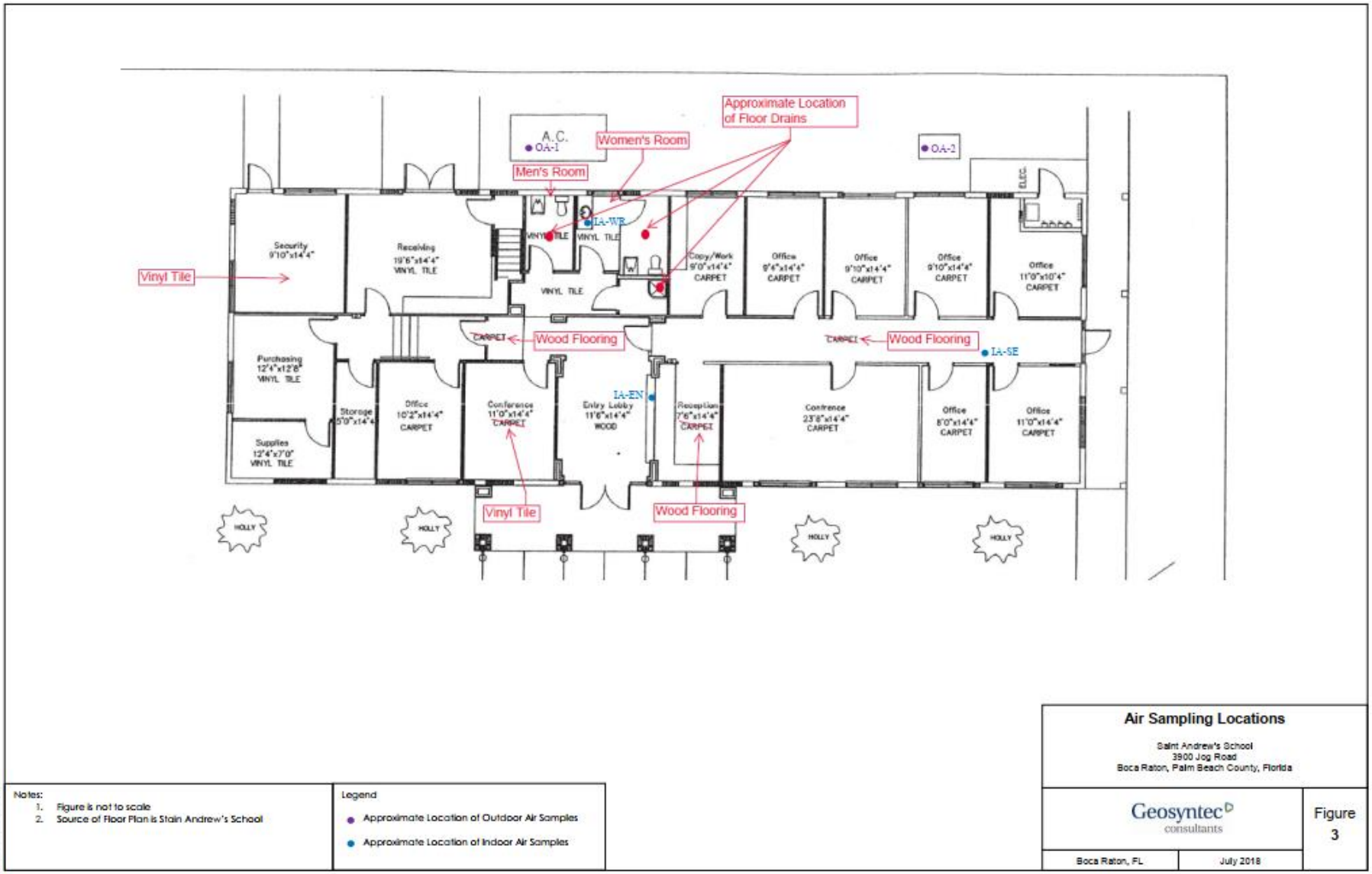

Figure 2: Air sampling location [Source: Geosyntec, 2018]

The major contaminant of concern is benzene. Benzene is a colorless liquid with a sweet odor that volatizes rapidly and slightly dissolves in water. Benzene is commonly found in the environment mainly due to industrial processes. If found in the air, it is likely from emissions of burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gasoline stations (ATSDR, 2007). In addition, industrial discharge, disposal of products containing benzene, and gasoline leaks from underground storage tanks release benzene into water and soil. Benzene is a chemical for which background levels must be considered. It is important to keep in mind that although chronic exposure to elevated levels of the chemical in indoor air may show potential risk, the concentrations detected at the Assaf Building were within levels considered by some investigators to be background. Indoor air background levels for benzene in non-residential environments range from 0.6 to 36 $\mu g/m^3$ and in some studies higher levels have been reported (Applegate & Warner, 2018; EPA, 2011a; Dawson, 2008; Rago, 2015).

3.3 Exposure Assessment

A human health risk assessment evaluates and characterizes the risk of a chemical found at the site causing possible harm to human health. The risk characterization includes a review of available environmental data and possible exposure pathways (ways people could be in contact with the chemicals), as well as a comparison of the test results with other screening values available from EPA and DEP. The ATSDR, EPA, and DEP screening values present the upper limit in the environment (air, water, or soil) below which we do not expect harm to human health.

Exposure can occur when a person is exposed to a chemical or a group of chemicals that are found in the environment such as air, water, soil, and/or food (exposure media). During the exposure assessment, the DOH health assessors consider these exposure media and measure/estimate possible ways (pathways) and intensity of someone being exposed to a chemical occurring in the environment, as well as how long and how often someone is exposed to this chemical (duration and frequency). The amount of exposure of a body to chemicals depends on the following factors, but is not limited to (1) the type of chemical, the concentration of the chemical present, (2) the exposure length (how long someone is exposed to the chemical) and (3) the exposure frequency (how often someone is exposed to the chemical).

Pathways For each investigated site, the health assessor determines possible ways (pathways) a person could encounter a potentially harmful chemical based on the characteristics of the site. When analyzing pathways, the following elements are assessed:

(1) the source of contamination,
(2) the environmental medium to hold or transport the source such as air, soil, or water,
(3) the exposure points where people encounter the chemicals,
(4) the exposure routes through which source chemicals enter the body, and
(5) the exposed population; the people who are exposed to the chemicals.

An exposure pathway can be:

- completed - when all five of the previous elements are present,
- potential - when there are one or more elements which cannot be identified, but it is possible that the element could have been present; and

- eliminated - when at least one of the elements is not present and will likely never be present.

Intensity The amount of exposure of a body to chemicals depends on the following factors, but is not limited to:

- The type of chemical, the concentration of the chemical present,
- The exposure length (how long someone is exposed to the chemical) and
- The exposure frequency (how often someone is exposed to the chemical).

Duration and Frequency When exposure occurs, some people may get sick when others are not affected. Every person can react differently to exposure. The degree of the reaction can depend on the factors mentioned above and/or on the overall health of the person that experienced the exposure. To assess how exposure could possibly affect the body, dose calculations are performed. A dose calculation estimates the amounts of a contaminant a person is exposed to and the amount that gets into their bodies based on body weight under specified exposure situations [EPA, 2011b].

3.4 Risk Characterization and Communication

When the exposure assessment is completed, the health assessors compare each calculated exposure dose to its corresponding health guideline. The health guideline is typically:

- ✓ ATSDR's risk levels and comparisons values [Minimal Risk Level (MRL), Cancer Risk Evaluation Guide (CREG), Environmental Media Evaluation Guide (EMEG)], and/or
- ✓ EPA Reference Dose (RfD), and/or
- ✓ the Florida Department of Health Advisory Level (HAL), and/or
- ✓ the Florida Department of Environmental Protection Cleanup Target Level (CTL), and/or
- ✓ Florida's Drinking Water Standards

The guideline used is the most protective. Health guidelines consider safe doses at which the site chemical concentration or calculated dose is at or below the dose for which DOH expects no harmful health effects. If the results are greater than the comparison values, the potential non-cancer and/or cancer health risks will be evaluated and communicated. When evaluating the cancer risk, DOH uses the '10^{-6} cancer risk evaluation', which means there is a risk of one additional occurrence of cancer in one million people, for the exposure scenario evaluated in comparison to a population that is not exposed.

Once DOH has summarized the risk assessment and characteristics, all collected information and recommendations are communicated in a ***Health Assessment Report*** or ***Health Consultation Report***. An assessment report discusses all the efforts and risk at the entire site while a consultation report mainly evaluates a specific question to a site. The risk assessment, risk characterization, and risk communication will help the involved parties such as EPA, ATSDR, DEP, DOH, and the parties responsible for the health risk at a site to select and implement options/alternatives to protect the community and its environment.

3.4.1 Exposure Pathway Analysis

The DOH health assessors identified the exposure pathways in which people might have gotten or will be in contact with the chemicals (Table 1). For this consultation, a completed exposure pathway analysis was done and shown below:

Table 1: Complete Exposure Pathway for vapor intrusion in the Assaf Building, St. Andrew's School site.

Source	Media	On-Site/Off-Site	Exposure Route	Receptor
Volatile chemicals in shallow groundwater at Assaf Building	Vapor Intrusion	On-site	Inhalation	Current indoor worker

Volatile chemicals in shallow onsite groundwater are a potential source for vapor intrusion for buildings. Vapor intrusion occurs when volatile chemicals in shallow groundwater enter soil gas and then buildings via cracks or other openings in the foundation. Without ventilation, volatile chemicals can accumulate in indoor air. Benzene is the only volatile chemical found in the air samples which exceeded the minimum risk comparison value.

3.4.2 Health Evaluation

Determining Comparison Values

As a part of the risk assessment, each exposure point data concentration is compared against a comparison value used by ATSDR. During the screening process, the highest concentration of each chemical is compared. If that value is below the ATSDR comparison value, further investigation is not warranted. However, if the value is above the comparison value, further evaluation occurs. The next step is to use the highest concentration in risk calculations to determine the likelihood of both non-cancer and cancer health effects.

Risk Calculations

The hazard quotient is used to determine the non-cancer effects. The hazard quotient is the ratio of potential exposure to a substance and the level where no adverse effects are expected. If the value is less than one, no adverse effects are expected to occur due to exposure. However, if the value is greater than or equal to one, then there is a probability of non-cancer health effects. It is imperative to understand that as the hazard quotient value increases, it does not equate to an increased risk of health effects.

Cancer risk calculation takes into consideration the contaminant causing the expose, the concentration of the contaminant, the frequency of exposure, and the length of exposure.

To put the increased cancer risk into perspective, we use the following descriptors for the different numeric cancer risks:

1 in 10 (10-1)	"very high" increased risk
1 in 100 (10-2)	"high" increased risk
1 in 1,000 (10-3)	"moderate" increased risk
1 in 10,000 (10-4)	"low" increased risk
1 in 100,000 (10-5)	"very low" increased risk
1 in 1,000,000 (10-6) or less	"extremely low" increased risk

Risk calculations for the Saint Andrew's School assumed exposure of 8 hours a day, 5 days a week, for 12 weeks (beginning of noticed petroleum odor until the vapor measurement was below risk levels). Even though the measured indoor vapor concentration decreased over the 12 weeks sample period (March through June), the DOH health risk assessor used the maximum concentration measured to evaluate the "worst case" scenario and to ensure that future mitigation will be protective of the public health.

The DOH health risk assessor collaborated with subject matter experts at ATSDR and used the following equations and data in Appendix A to assess the public health risk of vapors at the St. Andrew's School:

(1) Adjusted Maximum Concentration

$$\text{Maximum Concentration}_{adjusted} = \text{Maximum Concentration } (\mu g/m^3) \times CF$$

CF = Conversion Factor
CF = Exposure Time (hours/day) x Exposure Frequency (days/week) x Exposure Duration (weeks/year) x Averaging Time (years)

Equation 1

➢ ***Conversion Factor Adjustment:***
Vapor intrusion calculations followed ATSDR's Draft Air Exposure Dose Guidance (2018). Exposure times, frequencies and durations in the guidance document are provided for a residential scenario. As the administrative employees at Saint Andrew's School were assumed to be exposed to vapors for 12 weeks during business hours, vapor intrusion equations were adjusted to occupational exposure times, frequencies and durations (Table 2):

$$CF = \frac{CF_{Occupational}}{CF_{Residential}}$$

Equation 2

Table 2: Exposure times, frequencies, durations and averaging time for residential vapor intrusion scenarios and adjusted occupational scenario:

	Residential	***Occupational (Office Saint. Andrew's School)*** *-Cancer, Chronic-*	***Occupational (Office Saint. Andrew's School)*** *-Noncancer-*
Exposure Time (hours per day)	*24*	*8*	*8*
Exposure Frequency Day (days per week)	*7*	*5*	*5*
Exposure Duration (weeks per year)	*52.14*	*12*	*12*
Averaging Time** (years) cancer, chronic	*78*	***25***	--
Averaging Time** (years) noncancer	*33*	--	***25***

***Averaging time (AT): The period over which the exposure is averaged to arrive at a time-weighted exposure factor. For assessing cancer risks, AT is averaged over a lifetime (78 years for residential exposures); for assessing occupational and non-cancer hazards, AT is averaged over the exposure duration (days, weeks, or years), which may or may not be a lifetime (ATSDR, 2018).*

➔ **CF cancer (chronic)=** $\frac{8\ \frac{hr}{d} \times 5\ \frac{d}{wk} \times 12\ \frac{wk}{yr} \times 25\ yr}{24\ \frac{hr}{d} \times 7\ \frac{d}{wk} \times 52.14\ \frac{wk}{yr} \times 78\ yr} = \mathbf{0.018}$

➔ **CF noncancer=** $\frac{8\ \frac{hr}{d} \times 5\ \frac{d}{wk} \times 12\ \frac{wk}{yr} \times 25\ yr}{24\ \frac{hr}{d} \times 7\ \frac{d}{wk} \times 52.14\ \frac{wk}{yr} \times 25\ yr} = \mathbf{0.055}$

(2) Cancer Risk

Cancer Risk=Maximum Concentration$_{adjusted}$ x Inhalation Unit Risk

Inhalation Unit Risk = 2.2 x 10^{-6} to 7.8 x 10^{-6} µg/m^3
(Source: EPA's Integrated Risk Information System)

Equation 3

(3) Noncancer Risk

$$\text{Noncancer Risk} = \frac{\text{Maximum Concentration}_{adjusted}}{\text{EMEG}}$$

Chronic EMEG/MRL = 9.6 µg/m^3 (Source: ATSDR)*
**EMEG = ATSDR Environmental Media Evaluation Guides*

Equation 4

Using equations 1-4 and data in Appendix A, the DOH health risk assessor calculated following public health risk (Table 3):

Table 3: Risk calculation overview and results for Saint Andrew's School.

MAXIMUM CONCENTRATION (BENZENE)		12 µG/m^3
CANCER (CHRONIC)	CF	0.018
	Maximum Concentration$_{adjusted}$	0.216 µg/m^3
	Risk	4.8x10^{-7} to 1.7x10^{-6}
NONCANCER	CF	0.055
	Maximum Concentration$_{adjusted}$	0.66 µg/m^3
	Risk (HQ)	0.069

**HQ = Hazard Quotient*

These values indicate an extremely low additional cancer risk ranging from 0.5 cases in 1,000,000 to 2 cases in 1,000,000. The noncancer value (HQ) of less than one shows that no noncancer adverse effects are expected to occur.

4. Conclusions and Recommendations

a. Measured benzene concentration levels found in the indoor air of the Business Office Building (Assaf Building) were above screening levels and pose a possible health concern and were therefore further evaluated for public health risk. Exposure from this contaminant are not likely to cause non-cancer illnesses, but can lead to an extremely low risk of cancer.

b. The highest concentration of benzene is within the background levels previously discussed, which means that the benzene present is within the range of what is expected to be seen in this setting.

c. Inhalation of benzene vapor of 12 µg/m^3 in the Assaf building for 8 hours/day, 5 days/week, 12 weeks a year over a 25-year occupational period can cause an extremely low cancer risk. For chemicals that cause cancer, the general assumption in risk assessment has been that there are no exposures that have "zero risk" unless there is clear evidence otherwise. Very low exposures to carcinogens might increase the risk of cancer, if only by a very small amount.

d. The contaminants toluene, ethylbenzene, total xylenes, and methyl tert-butyl ether volatized in the air of the Assaf Building were below screening levels of which a health concern may is expected for workers and students. This is based on the data results provided by DEP compared to ATSDR's CVs. These chemicals are not expected to harm human health.

➢ **<u>Recommendations:</u>**

a. Assess and mitigate immediate threats to safety such as the potential of fire or explosion hazards.

b. Repair the current AV/SVE system to ensure proper ventilation and continue to monitor vapor concentrations.

c. Install additional ventilation equipment in the building until the AV/SVE system can work properly.

d. Continue monitoring the air quality to ensure public health safety until the vapor intrusion is properly mitigated.

5. Public Health Action Plan

➢ **Actions Completed (*Based on Geosyntec, 2018*):**

- ✓ In 1992, 355 tons of petroleum-hydrocarbon impacted soil were removed in the vicinity of the former underground storage tank located near the Assaf Building.
- ✓ During the advancement of soil borings in March 2013, soil screening was conducted using an organic vapor analyzer (OVA) equipped with a flame ionization detector (FID). Soil readings exceeded 100 parts per million (ppm) and samples exceeded DEP's industrial soil CTL.
- ✓ In March 2013 groundwater samples were collected and exceeded Florida's groundwater CTLs.
- ✓ A vapor intrusion study was conducted in August 2013. Organic vapor readings ranged from one to 315 ppm. Analytical results of a direct air sample were below the draft DEP and EPA indoor vapor intrusion screening criteria (GEOSYNTEC, 2018).
- ✓ In December 2015, supplemental assessment actives were conducted. Soil sample OVA readings exceeded 1000 ppm.
- ✓ A remedial action plan (RAP) was approved in December 2017 and included the use of AS/SVE system with underground piping and remediation equipment compound located west of the Assaf Building.
- ✓ The AS/SVE system was installed in 2017 following the specification explained in the 2016 RAP.
- ✓ The AS/SVE startup was conducted in October 2017.
- ✓ Following the AS/SVE startup, the system was shut down due to petroleum odors in the Assaf building.
- ✓ By the end of October 2017, the system was restarted using the SVE recovery only.
- ✓ During December 2017 and January 2018, the AS/SVE system was restarted and interior air vapor accumulation measured using an OVA reader.
- ✓ Beginning of January 2018, the AS/SVE system was shut down.
- ✓ DEP's contractor (Geosyntec) conducted organic vapor screening at the end of February 2018.
- ✓ In March 2018, Geosyntec conducted additional indoor air sampling. The indoor air sampling included the collection of three 8-hour, time-weighted average indoor air samples at the three locations identified inside the Assaf Building.

- ✓ Between March and April 2018, Geosyntec installed temporary air purifying units with activated carbon filters and provided carbon-filled air filters for the two HVAC air handlers present within the Assaf Building.

- ✓ In April 2018, Geosyntec continued to collect indoor air samples.

- ✓ Fresh air duct installation for two air handlers was conducted at the School on May 11, 2018.

- ✓ In May and June 2018, Geosyntec continued to collect indoor air samples.

➢ **Actions Planned:**

- ✓ DOH will review additional environmental data as warranted.

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APPENDICES

APPENDIX A: TABLES

Table A-1. Overview of Maximum Indoor Air Concentrations (March through June)- St. Andrew's School.

Exposure Point	Chemical	Date	Concentration (µg/m^3)	Location
Soil (on-site) VOCs Vapor Intrusion	Benzene	March 3, 2018	9.3	IA-WR
			7.0	IA-EN
			12	IA-SE
	Toluene	March 3, 2018	92	IA-WR
		March 22, 2018	1500	IA-EN
			830	IA-SE
	Ethylbenzene	March 3, 2018	14	IA-WR
		March 22, 2018	23	IA-EN
		March 3, 2018	21	IA-SE
	Total Xylenes	April 14, 2018	3.8	IA-WR
			9.4	IA-EN
			5.5	IA-SE
	Methyl tert-butyl ether	March 14, 2018	0.61	IA-WR
		March 22, 2018	2.9	IA-EN
			3	IA-SE

Table A-2. Exposure Adjusted Indoor Air Concentrations – Saint Andrew's School

Exposure Point	Chemical	Concentration (µg/m^3)	Adjusted Maximum Concentration Cancer (µg/m^3)	Adjusted Maximum Concentration Non-Cancer (µg/m^3)
Soil (on-site) VOCs Vapor Intrusion	Benzene	9.3	0.17	0.51
		7.0	0.13	0.39
		12	0.22	0.66
	Toluene	92	1.66	5.06
		1500	27.00	82.50
		830	14.94	45.65
	Ethylbenzene	14	0.25	0.77
		23	0.41	1.27
		21	0.38	1.16
	Total Xylenes	3.8	0.07	0.21
		9.4	0.17	0.52
		5.5	0.10	0.30
	Methyl tert-butyl ether	0.61	0.01	0.03
		2.9	0.05	0.16
		3	0.05	0.17

***The non-cancer and cancer exposure factor for each concentration is multiplied by the concentration measured in indoor air to get the adjusted indoor air concentration.*

Table A-3. Comparison Value Data to Determine Contaminant of Concern.

Chemical	ATSDR Comparison Value ($\mu g/m^3$)	Adjusted Maximum Concentration Cancer ($\mu g/m^3$)	Adjusted Maximum Concentration Non-Cancer ($\mu g/m^3$)	Contaminant of Potential Concern (COPC) Flag (Y/N)	Rational - Above/Below Screening Level (ASL/BSL)
Benzene	**ATSDR CREG 0.13 $\mu g/m^3$**	**0.22**	**0.66**	**Y**	**ASL**
Toluene	ATSDR Chronic EMEG 3,800 $\mu g/m^3$	27.00	82.50	N	BSL
Ethylbenzene	ATSDR Chronic EMEG 260 $\mu g/m^3$	0.41	1.27	N	BSL
Total Xylenes	ATSDR RfC 23 ppb	0.17	0.52	N	BSL
Methyl tert-butyl ether	ATSDR Chronic EMEG 700 $\mu g/m^3$	0.05	0.17	N	BSL